

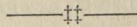
UNIVERSITY OF CALIFORNIA.

AGRICULTURAL EXPERIMENT STATION.

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ROOT KNOTS ON FRUIT TREES AND VINES.

INTRODUCTORY NOTE. — The subject upon which Prof. Woodworth makes the following interesting statement has perplexed California fruitgrowers for many years. Almost everything imaginable has been cited as a probable cause; conditions of drouth or of excessive moisture were among the earliest causes assigned, and some prejudice against nursery stock grown by irrigation was created. An investigation by a committee of the State Horticultural Society about 1880 showed that the knotted roots were found quite as abundant in unirrigated land as in irrigated, and otherwise the inquiry yielded no definite results. For some time many nurserymen followed the practice of removing the knots from the trees as dug from the row, but this was abandoned when it was found that the knot commonly reappeared after planting in the orchard. At present no reputable nurseryman sells such trees; they are burned at the nursery.

In my personal examination of knots, which has continued for 15 years, I have but on one occasion found a nematode gall and that was upon the root of an English walnut sent from Los Angeles county. Nearly all the others were of the character described by Prof. Woodworth as "crown galls," although they are found in many cases farther down on the roots. Some orchardists have been at great expense in laying bare the roots and smoothly paring the

roots and applying various substances to the roots. In most cases the knots have reappeared subsequently. Others have laid bare the knot-burdened root crown to the sun and the knots have flaked off, but others have been found afterward lower down on the roots.

It must be acknowledged that the cause of the evil and its cure are still unknown, and it is to be hoped that Prof. Woodworth's study of the subject, which is still in progress, may reach definite conclusions. His advice not to plant a diseased root should be zealously adhered to by all planters. Probably during the last 20 years, hundreds of thousands of such trees have spindled and died in the best soil and with the best treatment. If the disease has stunted the growth of a young tree, pluck it out and plant a new one. If knots are found on larger trees, which are making satisfactory growth in spite of them, remedial measures should be tried. The final result seems to depend upon whether the natural or the diseased growth secures the ascendancy early in the life of the tree, for apricot trees have been taken up after 30 years of satisfactory growth and bearing, and found to have roots badly infested with the knots.

E. J. WICKSON,
Acting Director.

There is no one thing about which so many inquires have been received as a peculiar form of root-knot or gall on a number of plants, but chiefly grape and apricot. These

knots are of irregular shape, fleshy and mostly situated at or about the crown of the roots.

On different plants they present a somewhat different appearance, but they are so near alike in structure as to prove that they must all be due to practically the same causes.

This form of gall has received a number of local names, the most widely used of which is that of "black knot," particularly for the form that occurs on the grape. This is an objectionable name, as it has long been used in the eastern States for a very different kind of gall that occurs on the stems of cherries and related plants. On account of its presence at the crown of the root, almost invariably, it may be called the crown gall or knot, so as to distinguish it from other forms of root galls, of which there are quite a number of kinds, sometimes with much the same general appearance as the crown gall, but which show a decided preference for the other parts of the roots.

The crown galls arise generally from one side of the crown as a simple swelling of fleshy substance of about the consistency of a potato or perhaps somewhat harder. They soon become irregularly granular over the surface and dark-brown in color, the outer parts of the granulations into which the surface is divided being the darkest. When cut or broken open they are almost white at first, but very soon become reddish-brown on exposure to the air. Under the microscope, they may be seen to be composed of large, thin-walled cells, with now and then the distorted and scattered elements of the fibro-vascular bundles.

A young gall of this kind contains very much water, and on drying, becomes sponge-like in appearance, and is very light and quite hard. Older knots are similar, but harder, and dry into harder and firmer masses, which do not shrink or become sponge-like. In size the crown gall varies greatly, being often as large as one's fist and sometimes much larger, especially in the apricot.

Of other root galls, we may distinguish five different kinds :

1st. Mechanical galls, which are slight swellings, sometimes produced at points where the roots meet obstructions, and are quite common on the roots of some plants in a stony soil. They may be told at once from a crown gall by their comparatively smooth surface, and by the fact that they only accompany an abrupt bend of the root. They are only slight swellings and flattenings of the root, and are seldom found anywhere near the crown. Indeed, they are the form of root gall least likely to be mistaken for the crown gall.

2d. Louse galls due to the attacks of plant lice. Those caused by the phylloxera and woolly aphis are well-known examples. They are almost always of small size, occurring on both large and small roots, and as often at the crown as elsewhere. The presence of the lice is generally sufficient as a distinguishing character, though their small size may render them hard to be seen.

3d. Tubercle galls found only on the roots of plants of the pea family. Only the smaller roots are affected. The gall is about an eighth of an inch or less in diameter, the whole inside of which is swarming with minute moving particles which appear to be bacteria. They play an important role in the acquisition by the plant of nitrogen from the air. The small size of these galls and their presence only on the small roots will distinguish them from the crown galls.

4th. Club-foot galls produced by a slime-mold (*Plasmodium brassicae*), on the roots of cabbages and such plants. These galls are somewhat yellowish when broken open, which color is due to the presence of the slime-mold in great abundance in the diseased tissues of the gall. They may be distinguished from the crown galls by not being so knotlike, but being much more closely attached to the plant.

5th. Nematode galls which are due to minute worms resembling very much the so-called vinegar eels. They are found on the roots of a great number of plants. The worms are so small that ordinarily they will not be seen without examining sections

under the microscope. The small size of the gall, and its presence chiefly on the smaller roots, will distinguish it from the crown gall.

There are several theories as to the cause of the crown gall, but none of them are without very serious objections. One idea is that these galls are the result of wounds made in cultivation, and I think it has been proven that at least in a few cases the galls have followed such wounds. In attempting to heal a wound, as is well known, the plant will often produce at that point a slight swelling, and it is argued that at the crown the conditions are such that a large swelling will result. There are, however, a number of fatal objections to this hypothesis. Neither is the crown gall the uniform result of a wound, nor is a wound, at least one made by human agency, necessary to produce a gall, though it would be bold to assert that there had never been a wound of any kind at the point where the gall is produced. The most fatal objection to this hypothesis is the fact that the appearance, the manner of growth and all the phenomena connected with the crown gall are so different from those of a healing wound that there seems scarcely any reason to connect the two.

Another theory is that they are due to peculiar conditions of the weather, such as frosts, excessive rains and such things at a critical time in the spring, causing an abnormal stagnation or an excessive flow of sap, and the gall is the result. These suppositions are scarcely reconcilable with the facts of plant physiology, and it has never been observed that these galls are produced in particular abundance immediately following any peculiar spring condition. Indeed, the idea seems to arise from the general tendency to ascribe every abnormal condition of a plant to the weather.

A third theory is that they are due to some of the fungi related perhaps to that which produces the true black knot. The only objection to this theory is that no such fungus has ever been observed about the knots, at least not in the living knots, and it may be that a more careful study than

has yet been made will show that such fungus does occur.

Finally, as has become quite the fashion of late years, the bacteria have been charged with the injury. I myself have succeeded in getting pure cultures of a micrococcus from the inside of some of the knots, after taking all the usual precautions to prevent accidental contamination. I do not succeed, however, with all knots of this kind, and not having further evidence, such as, for instance, the communication of the disease to healthy plants, we are not in a position to say that we have found the cause.

The presence of a gall at the crown of a plant seems to effect an obstruction to the flow of the sap, and in this way a tree or vine becomes weakened and finally dies. The gall generally attacks small plants, but not always, and it often takes a number of years before the plant is killed.

Whatever the cause, many fruitgrowers in California have had reason to know the seriousness of the injury produced, so the following words in regard to remedies and prevention will not be out of place. Not knowing the cause, they can be but suggestions, but it is believed that the treatment laid down is the safest procedure.

First, in the orchard the knots should be carefully removed and burned as soon as found, and an antiseptic application made to the tree where the knot has been removed. We would recommend Bordeaux mixture for this purpose. Trees so treated should be examined from time to time for at least a year, and should the knot reappear, it would be best to remove and destroy the whole tree. When a tree is removed, it would be well to delay resetting for a year or two, or to reset with a tree of an unsusceptible kind.

Second, when setting an orchard, reject all stock affected by the knot. I would prefer to have stock from a nursery known to be entirely free from it.

Third, in the nursery the greatest care should be taken to destroy by burning everything showing any evidence of the disease. Fields in which these galls have appeared should be devoted to some other crop for a number of years.

C. W. WOODWORTH,

December 1, 1892.

Berkeley, Cal.

A NEW NOZZLE TESTER.

The latest acquisition in the line of apparatus for experimentation is a new nozzle-tester that has just been constructed at the University of California. There are many kinds of spray nozzles on the market, and excellent ones, too, but they are of widely different types and so are not equally suitable for the same use. There has not been as yet any attempt to determine carefully and accurately their relative merits. This the University Experiment Station now proposes to do.

The most conspicuous part of the new nozzle-tester is a large tank intended to maintain a constant pressure. From the lower part of this tank a large pipe leads to the apparatus, to which the nozzle is attached. The large diameter of this pipe makes the friction of the water flowing through it practically nothing. Just before the point where the nozzle is attached there is a steam gauge to register the pressure and a mercury manometer for determining more accurately the lower pressures. It is hardly worth while at present to attempt to describe the various contrivances for the accurate measurement of the action of the nozzle and of the spray, as they will all be fully described and illustrated in a later bulletin, where also the results of actual tests of the more common nozzles in the market will be given.

The data that will be determined for each nozzle under different pressures is as follows:

1. Volume of discharge per second.
2. Velocity of steam just in front of the nozzle.

3. Distance the spray is thrown.
4. Angle of dispersion.
5. Average fineness of spray.
6. Distribution of spray.
7. Uniformity in fineness.

It is believed that by such a study of new nozzles the following questions may be settled:

1. The best types of nozzles for particular purposes.
2. The conditions under which each nozzle gives its best results.
3. The changes in the construction of any nozzle which will make it more available for any particular purpose.

We also intend to study old nozzles, comparing them with new ones of the same kind to determine:

1. The cause and amount of deterioration.
2. Changes in construction which might overcome these defects.

We would like to receive from manufacturers and dealers in spraying apparatus specimens of their nozzles for experiment. For the study of old nozzles we would likewise request fruitgrowers and others to forward to us their old nozzles together with a statement as to the extent and kind of washes that have been used in them. The data in regard to all nozzles tested will be published in full with illustrations in the bulletins and reports of the Experiment Station, and the nozzles will be preserved and exhibited in the museum of the department.

C. W. WOODWORTH.

Berkeley, Dec. 16, 1892.